TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XVIII, No. 12. DECEMBER, 1941. PRICE 6d.

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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

RESISTANCE OF PLANTS TO INSECT ATTACK.*

THE choice of plant varieties with reference to their ability to produce satisfactory yields in the presence of insect infestations is far from new and has been recognized during a period of about one and a half centuries. Resistance has come to be the term in common usage, and in recent years has been used in its widest sense to include those characteristics which enable a plant to avoid, tolerate or recover from the attacks of insects under conditions that would cause greater injury to other plants of the same species.

It is plainly evident that interest in the resistance of plants to insect attack has greatly increased.† Thus, problems of plant resistance have received much attention in recent years, and there are now records of resistance in nearly 100 plant species, and over 100 insect species are involved. Although it is generally realized that the methods of controlling certain insect pests by the use of insecticides and cultural practices have their limitations, these methods all have and will nevertheless continue to have their place in agriculture. Likewise, breeding varieties of crops resistant to insect attack has its limitations, for the length of time that a resistant variety will remain resistant is a matter of speculation, and too much should not be expected from such resistant varieties.

Immune varieties are extremely rare in nature and what is called resistance often implies little more than a low degree of susceptibility to attack. The development of resistant varieties, however, has sufficient promise to warrant attention in connection with the general field of insect control, and deserves consideration in any plant breeding programme. In many cases it is necessary to select strains of plants that have a fair degree of resistance combined with many other desirable characteristics in preference to those that have the highest possible resistance.

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* Abridged from a paper of the same title by R. O. Snelling, *Bot. Rev.*, **7**: 543-586, 1941.

† Symposium on resistance of plants to insect attack of American Association of Economic Entomologists, 1941. (5 papers by R. O. Snelling, J. H. Bigger, C. M. Packard, S. F. Bailey and R. H. Painter, *Jour. Econ. Ent.* **34**, 1941.)

It is probable that in most cases no single plant character is responsible for a variety surviving insect attack. The plant characteristics that have been suggested as having an influence upon insect resistance are so numerous and vary so widely that a satisfactory classification is difficult, but they can be assigned to three main categories: physical, chemical and physiological.

Crop plants frequently thrive over a greater range of temperatures than can the insects which attack them, and for this reason certain varieties have in some cases been considered to be resistant, although this is not strictly an instance of resistance in the plants but one of evasion. The use of early maturing varieties of cotton and early planting dates has been recommended as a means of overcoming boll weevil injury. Early ripening varieties of rice have been recommended because they suffer less damage from leafhoppers than later maturing varieties.

Certain varieties of crop plants are known to be unattractive to insects. This may result in a smaller number of insects feeding on a variety and in some cases a smaller number of eggs being deposited. While the resistance of some varieties is dependent upon the absence of certain chemical substances or conditions attractive to the insects that attack them, others are resistant because of the presence of substances that repel the insects. This is well illustrated by the resistance of certain wood to termites. In this case the insect is repelled from wood possessing certain chemical constituents. Resistance to termite attack seems to be often independent of the hardness of the wood, although most very hard woods are actually resistant. However, with certain other insects hardness of the tissue seems to have a very marked influence on the resistance of a variety. In sugar cane, among other crops, varieties have been found resistant to several insect pests because of the hardness of the tissue.

The pubescence or hairiness of the stems and leaves of certain varieties of alfalfa, soy beans and cotton has been shown to be of importance in connection with leafhopper resistance. Jassid-resistant cottons show marked hairiness, but not all hairy strains are necessarily highly resistant. The qualities which constitute this resistance are not understood, and it appears that hairiness may be mainly the outward expression of such unknown qualities.

The thickness of certain plant tissues and the resistance of certain tissues to puncturing have been shown to have an important bearing on the resistance of plants to certain insects. This characteristic may prevent feeding or satisfactory oviposition. A number of plants with a tendency towards a thicker epidermis and cuticle show resistance to various sap-sucking insects. The influence of thickness of tissue upon oviposition is illustrated by the inability of the papaya fruit fly to reach through the flesh of the fruit of certain strains of papaya and satisfactorily oviposit its eggs.

The growth habit, including both the rate at which some varieties grow and the type of growth, has been suggested as having an influence on resistance. Thrips resistance in onions is fairly well understood, and has been associated with the shape of the leaves, the angle of divergence of the two innermost leaves, and the distance between the leaf blades on the sheath column. These characters help to restrict the thrips population, while other characters, not yet clearly elucidated, help the plants to withstand injury. The only other work that appears to have been done on thrips resistance is that on the gladiolus thrips. Observations tend to show that some or all of the following characters are of importance in thrips-resistant varieties of gladiolus: early blooming, rate of growth, natural vigour, tightness of leaf sheath, colour of leaves and flowers and chemical composition of the sap. This emphasises the fact that resistance in plants is usually not due to a single character, but that a number of factors are involved in conferring resistance.

The ability of some varieties to recover after attack is also of great importance, although this is perhaps not strictly a case of actual resistance in the plant. The ability of certain varieties of sugar cane to reproduce roots following the attack of white grubs is of interest in this connection. Work on the resistance of sugar cane to froghopper attack has shown that, while on the whole the thick noble canes suffer more injury than the thin canes, the most important factor influencing resistance is the ability of certain varieties to recover from the attack.

Finally, the resistance of varieties of crop plants depends not only upon their inherent resistance, but also upon their adaptation to soil, climate and other environmental factors. The inherent resistance of some plants has been shown to be considerably modified by changes in environment. For example, some varieties of rice have been shown to be resistant to leafhoppers on certain soils and to be severely attacked on other soils. Again, certain varieties of tea have been shown to be resistant to the tea mosquito bug when provided with an optimum supply of soil moisture, but the resistance was reduced under conditions of either excessive or inadequate water supply.

A sound knowledge of the factors conferring resistance and the conditions which influence these factors is the basis of breeding plants for insect resistance, but it is not necessary thoroughly to understand these factors in order to initiate a breeding programme. Breeding crop plants for insect resistance is not fundamentally different from breeding for various other desirable characteristics, and should be included in any generalized plant breeding programme.

Four methods are in use for the development of resistant varieties of plants: *introductions* from either foreign countries or other localities, which provide a source of greater resistance than may exist in local strains, *selection* of strains from varieties or introductions or hybrids to improve resistance and retain other desirable characters, *hybridization* between resistant species or varieties and those not resistant but possessing otherwise desirable characters, and *grafting* of otherwise desirable but susceptible species or varieties upon resistant strains.

Although in many cases it may not be possible to find and develop crop varieties resistant to specific insects, the favourable results to date in many instances indicate the importance of investigating this method of control and justify the increased interest in this field.

E. McC. C.

VANILLA CURING.

[*The following note is taken from an article by Messrs. A. K. Balls and F. E. Arana of the U. S. Bureau of Chemistry, Washington, D.C. and the U.S.D.A. Experiment Station, Mayaguez, Puerto Rico, respectively, which was published in "Industrial and Engineering Chemistry,"* Vol. XXXIII, pp. 1073-1075, 1941.]

THE methods of curing the pods of *Vanilla fragrans* in order to develop the characteristic flavour and aroma of vanilla are not only empirical but also quite traditional. They have been handed down from father to son since Aztec times with little modification and no chemical basis. The curing of vanilla thus offers an interesting field for biochemical investigation, because the possibilities of improving the present empirical methods are considerable; the crop is also valuable. The amount of vanilla imported into the United States in 1939 was 1,018,000 pounds, valued at $3,502,000, according to the Foodstuffs Division, Department of Commerce. This represents an extremely high return per acre of the land employed, when the cultivation is successful. Successful cultivation, however, is no easy matter.

The curing process consists of four stages. The pods are wilted and then "sweated"—*i.e.* kept at 45° to 65°C for several days. The pods are next dried in air to the desired moisture content (until about two-thirds of the original water has been lost), and finally "conditioned" by storage in a nearly airtight container for six months or longer.

The Mexican method of curing, first practised by the Aztecs, consists of wilting the pods in the sun and then wrapping them in blankets where they are kept warm by intermittent exposure to more sunlight. After this treatment, the pods are dried and conditioned. The Bourbon process, used in the French islands of the Indian Ocean, whence most of the world's vanilla comes, achieves the wilting by dipping the pods into hot water. They are then sweated in warm ovens, dried on racks, and placed in a zinc-lined "conditioning-trunk". Many variations of the wilting process are known. Sometimes the pods are rubbed with alcohol; at other times they are scratched with a needle.

As the curing process progresses, the aroma of vanillin develops in the heretofore odourless pods. During the conditioning period, crystals of vanillin frequently appear, and the pods take on the characteristic fruity flavour of natural vanilla. Initial treatment of the pods with ethylene has recently been found to hasten the curing process and to improve the quality of the final product.

It is evident from the work of earlier investigators that vanillin, which is not present in the green pod, is produced by the hydrolysis of a vanillin-containing glucoside. Apparently this action occurs early in the curing process, yet the full aroma of vanilla develops only after a lengthy period of storage.

The authors' contribution to the problem of vanilla-curing lies mainly in their discovery that the traditional methods of curing really owe their efficacy to enhanced oxidation, whereby certain changes rapidly occur, resulting in the formation of desirable aromatic compounds. On the other hand, freezing was found to bring about the contrary result. Vanilla pods contain a considerable amount of peroxidase enzyme, which forms one component of a complex peroxidase system, comprising a phenol, an organic peroxide and peroxidase.

The authors suggest that vanillin is an intermediate product in the development of full aroma, and that certain *oxidation products* of vanillin may form part of the final mixture of aromatic substances whose presence in traces confers on the cured vanilla pod its very characteristic flavour and smell. It has been known for some time, of course, that vanilla pods cannot be evaluated merely on their content of vanillin, nor can synthetic vanillin, even when purified, replace cured vanilla pod or its extracts in the commercial market.

F. H.

PROGRESS IN CONTRIBUTING COLONIES OF SEEDLINGS RELEASED BY THE BRITISH WEST INDIES CENTRAL SUGAR-CANE BREEDING STATION.

By A. E. S. McIntosh.
(*Geneticist.*)

Introduction.

This article is concerned primarily with the commercial results achieved or likely to be achieved by seedlings released from the Station rather than with methods adopted in breeding and selecting. It is, however, considered better for a clearer understanding to give a brief outline of the routine adopted in selection for and despatch to the several contributing colonies.

Seedlings of purely noble-cane (*Saccharum officinarum*) derivation which are selected in Barbados at the end of their second season of test are multiplied for further tests in Barbados and, at the same time, sent to the Plant Quarantine Station in Trinidad for quarantine prior to liberation to the other colonies. Seedlings of such derivation are expected to be of use only in fertile soils where mosaic disease is absent or at least controllable. Such conditions exist to a greater or lesser extent in all the colonies served by the Station so that a general distribution is recommended. During the period of quarantine, which lasts approximately eighteen months, a third season of test has taken place in Barbados. With the additional information derived from this more extensive series of tests the Station is able to advise the Plant Quarantine Station whether any of the seedlings sent there after the second test should be discarded. It may happen that some have already been released from quarantine, in which case the advice to discard prior to multiplication is sent direct to the authorities of the receiving colonies. It should be mentioned here that noble cane seedlings released from Barbados to the Plant Quarantine Station have in Barbados already been proved to be resistant to gumming disease (*Bacterium vasculorum*) while their susceptibility to mosaic is taken for granted.

Seedlings of nobilised derivation, *i.e.*, derived from at least two *Saccharum* species, one of which is *Saccharum officinarum* are also sent to the Plant Quarantine Station after selection in their second year test. All, however, are not further tested in Barbados since many are not considered suited to Barbados conditions. Selections among second season test nobilised seedlings are for three broad categories, *i.e.* (1) general purposes, *i.e.* seedlings considered suited to at least a wider range of soil conditions than seedlings of purely noble cane derivation, (2) intrinsically infertile conditions, *i.e.* seedlings considered of a hardy nature and (3), areas where mosaic disease is dominant on susceptible varieties and require seedlings with commercial resistance to the disease : this includes both fertile and infertile cane growing areas. Categories (2) and (3) do not occur in Barbados and seedlings selected for them are not as a rule further tested in Barbados except they indicate suitability to Barbados conditions. Thus, the number of seedlings of nobilised derivation sent to the Plant Quarantine Station is always greater than that retained for further test in Barbados. As with seedlings of noble-cane derivation, so with the nobilisations further tested in Barbados, information after the third season's test can be given the Plant Quarantine Station or the receiving colony as to discarding prior to liberation or multiplication respectively.

Despatch of Seedlings from the Cane Breeding Station.

The Station was started in 1932. The contributing colonies are Barbados, Trinidad, Jamaica, the Windward and Leeward Islands. The first consignment of seedlings was sent in November, 1934, and one or two lots have been sent each year since. For convenience in presentation these are classified into seedlings of (1) noble and (2) nobilised derivation.

(1) Seedlings of Noble Cane Derivation.

To date, forty-three of this class have been despatched to the Plant Quarantine Station. The majority of these has been discarded prior to field testing as a result of information derived in subsequent tests in Barbados or in view of obviously better—more especially nobilised—seedlings following them in the selection series. The best of this forty-three are :—B.2935, B.3013, B.3127, B.3439. Details about each are given later in this article.

The nobilisation work started in Barbados in 1928 has reached the point of producing seedlings appreciably superior to purely noble-cane derivatives. Purely noble-cane breeding was therefore stopped in 1940 and it is unlikely that any noble cane seedling released subsequent to the B.34 series will become a commercial variety.

(2) Nobilised Seedlings.

These are derivatives of crossing wild species with the noble species *Saccharum officinarum* and back crossing progeny to noble species. Actually, the degree of back-crossing varies and further, crossing has been effected between derivatives of nobilisation of different species. All resulting seedlings are, however, for convenience referred to here as nobilised seedlings. In all, eighty nobilised seedlings comprising selections from the B.29 to the B.39 series inclusive have been sent to the Plant Quarantine Station. Of this eighty, twenty-eight were sent

to Jamaica only with a view to obtaining mosaic disease resistance data, twenty-one of hardy appearance were sent to colonies which include in their cane growing areas, areas of poorer soil, *i.e.* Trinidad, Jamaica and Antigua, while thirty-one considered to be general purpose types were sent to all colonies. Jamaica has thus received the greatest number of seedlings : this in view of being the only contributing colony where areas exist in which mosaic disease on susceptible varieties is uncontrollable. Such areas occur in both fertile and infertile soils so that both thicker cane and also hardy types resistant to mosaic are necessary.

All seedlings received by Jamaica have been tested for reaction to mosaic disease. This has served (1) to give some idea of reaction by seedlings to the disease in Jamaica as compared with reactions in Barbados (2) to indicate mosaic resistance inheritance trends with a view to guiding future breeding work for Jamaica, and (3) to ascertain the degree of resistance shown by individual seedlings with a view to allocating each to field trials.

It has already been found that reactions to mosaic in Jamaica are different to those in Barbados and this is probably due to the existence of different strains of the virus in the two colonies. It follows that mosaic disease resistance tests in Barbados will not serve for Jamaica and information on mosaic disease resistance inheritance will have to be derived from Jamaica.

At present, in the absence of sufficient data on mosaic disease resistance inheritance, selections for resistance are based purely on the parentage of the seedlings. With the accumulation of data in Jamaica from the seedlings despatched, this selection should in future become more effective.

In general it may be stated that in Jamaica the majority of the seedlings sent has proved susceptible to mosaic disease. It is to be admitted, however, that the tests so far conducted in Jamaica were situated in an area where mosaic disease is especially virulent and that the results of these tests need not necessarily and indeed, are not likely to be an indication of reaction to mosaic in the majority of the cane growing areas in Jamaica. To meet this situation, a new scheme of testing seedling resistances is to be put into effect whereby all seedlings showing sufficient growth promise in the early multiplication stage (which is being done in an area of light mosaic infestation) will be further multiplied and observed in areas representative of the entire Jamaican sugar-cane growing areas. During this stage of multiplication and observation, reactions to mosaic disease will be noted. It is felt that many of the seedlings already condemned for susceptibility to mosaic under the pre-existing conditions of severe test will survive as showing appreciable commercial resistance to the disease in the majority of the cane areas in Jamaica.

Progress with Seedlings in the Contributing Colonies.

Since the period of quarantine lasts about eighteen months and the colonies, on receipt of quarantined material, have to multiply the limited amount of planting material received, it follows that Barbados is ahead in the testing programme by at least two years. Thus, for more recent seedlings, conclusive data for Barbados only is available. With the experience gained in the performances of seedlings of previous consignments, both in and out of Barbados, it is possible to forecast reasonably accurately from the data derived in Barbados for these recent seedlings how they will perform elsewhere. Accordingly, performances of seedlings will be considered under three heads, *i.e.* (1) seedlings which have been tested in field trials in all colonies and for which definite conclusions on commercial value may be made (2) seedlings so far tested extensively in Barbados only and for which some forecasts as to their usefulness to other colonies may be made and (3) outstanding seedlings of more recent origin than those in (2) which are expected to do well in all colonies.

Seedlings Extensively Tested.

Under this head it should be noted that seedlings of the series B.29' to B.34' inclusive only have been well tested. This includes both noble and nobilised seedlings which, after their quarantine period, have been recommended for test by the Station. Thus, of the thirty-two noble and sixteen nobilised seedlings originally sent, seven and six respectively only were recommended for field test. The outstanding seedlings in the tests proved to be—B.2935, B.3439, B.34104, and to a lesser extent B.3013, B.3127, B.3254, B. 3172, B.34110. These are described here, special emphasis being placed on the first three.

B.2935.

This is a noble cane seedling, its parentage being Ba. 11569 and Ba.6032.

It germinates rapidly, bunches quickly and tillers reasonably well, cane growth is fast, arrowing scanty or absent, trashes well with a fair fall of trash ; canes are long and thick with average number in the stool : ratoons well only in good ratooning soils : easily milled, low megasse yield and poor burning properties, juice quality average.

Susceptible to mosaic and root diseases, resistant to gumming disease.

Suited to good soils only in lower rainfall areas, where it gives high yields of plant and ratoon cane.

In Barbados this seedling entirely supplanted the low rainfall area standard variety—Ba.11569 and in 1940 occupied over 40 per cent. of the cane growing area. It was largely responsible for the recent increased sugar crop in the Island. In St. Kitts it eliminated S.C.12/4 and Ba.11569 in the lower rainfall areas and came to occupy over 50 per cent. of the sugar-cane area. In

Antigua, it eliminated B.4507 in the better drained low-rainfall limestone soils (about 20 per cent. of the cane area) although Ba.11569 held its place against it in limestone soils with poorer drainage and liable to encourage root diseases. In Trinidad it has little value under the generally prevailing conditions of high rainfall and heavy soils while in Jamaica its susceptibility to mosaic debars it from serious consideration.

B.2935 will almost certainly be replaced by B.3439 and B.34104 while the latter in some areas will probably be replaced by B.37161 and B.35245.

B.3439.

This also is a noble cane seedling, its parentage being Ba.11569 Q(ueensland) 813.

It germinates readily, bunches early and heavily, cane growth is fast, canes are many in the stool and medium width, arrowing intensity is variable, from very heavy to complete absence, trashes well and gives exceptionally heavy fall of trash, canes keep very sound during crop. Ratooning in general very good, although occasionally patchy ratoon springs may be seen: milling and juice qualities in general excellent.

Resistant to root and gumming diseases, reaction to mosaic variable.

This is probably the best general purpose noble cane ever produced in Barbados although curiously enough it is less suited to Barbados itself than to the other contributing colonies.

In Barbados its performance relative to other varieties is entirely dependent on the season. In a season of early and prolonged rainfall practically every cane arrows. (It is to be noted that conditions in Barbados are more favourable to arrowing than anywhere else in the West Indies). This intense arrowing precludes any increase in tonnage from late growth. Although juice qualities are excellent, tonnages are not so good relative to the other scanty arrowing types. In average and more especially below average rainfall years, arrowing is much less marked and growth is prolonged throughout the season. Under these circumstances, B.3439 gives relatively high cane yields. It is at all times a good ratooning cane. In Barbados it is susceptible to mosaic disease.

In Antigua it has performed exceptionally well and consistently in tests carried out under widely different soil and rainfall conditions, and it is safe to say that for some years at least it will function as the chief standard commercial variety, replacing both B.2935 and Ba.11569.

In St. Kitts it appears to be definitely superior to B.2935 in cane yield, juice quality, soundness during crop and fall of trash. It is probable that it will be grown to the exclusion of the latter and may also encroach on part of the B.H. 10(12) acreage.

In Trinidad, according to Turner's Summary of Results of Varietal Experiments, 1941, it has outyielded the standard B.H.10(12) on five types of clay soils and on the so-called Washington series and also the standards Co.213 and Uba on comparatively infertile soils of the Usine Ste. Madeleine. The latter is a striking proof of its wide range in adaptability.

In Trinidad, where weeding costs are high, the habit of B.3439 of closing in rapidly as opposed to the slow closing in of B.H. 10(12) is a further advantage. It is probable that B.3439 will come to occupy a large percentage of the sugar-cane growing area in Trinidad.

In Jamaica, it is showing a high degree of resistance to mosaic, a surprising feature for a noble cane. Results of its reaping in field trials are available only for the 1940 crop. Here, it was reaped at four places, as plant canes. At all places, it emphatically outyielded the standard, B.H. 10(12), in sugar yields per acre. With these superior yields as plant canes and the high degree of resistance to mosaic and provided it ratoons well, B.3439 is certain to be grown on a large scale in Jamaica, displacing both B.H. 10(12) and P.O.J.2878 and may even succeed under the difficult soil and climatic conditions of the Trelawney cane areas.

Certainly, no noble cane produced in Barbados has had such a wide range of adaptability, from good soils of high and low rainfall to infertile soils, and areas where mosaic disease is virulent. Its commercial exploitation has only begun, but already it seems evident that it will soon be the major variety in the British West Indies.

B.34104.

This is a nobilisation, its parentage being Co.281 × B.H.10(12). The second season's test from which it was selected was reaped in Barbados on the 7th of February, 1936, that is to say, very early in the crop period. The standard was B.2935 and results from B.2935 and B.34104 were as follows:—

	Canes. Tons per acre.	Sucrose per cent. in juice.	Average number canes per plot.
B.2935	34	15·35	105
B.34104	38	19.70	198

Thus the cane yield was somewhat better than the standard and the juice quality exceptionally high. It is to be noted that the individual canes are much lighter than the standard. Indeed, it is a medium-thin cane type and, at that time in Barbados, there was a decided prejudice against thin-cane types. Accordingly, it was despatched to the Plant Quarantine Station and recommended for release as a hardy type to Trinidad, Antigua and Jamaica. At the same time, in Barbados it was planted in the breeding plots to serve as a future parent plant.

Its performance in the colonies to which it was originally recommended for test has been so striking that it has now been sent to all colonies

and in Barbados is now in a comprehensive series of tests. This is a good example of a thin-cane hardy type of seemingly general adaptability. The description is as follows :—

Germination excellent, tillering early and profuse, growth at first slower, but later, when tillering slows down, becomes fast, canes medium-thin, well above average number per stool, leaves form a dense canopy and weed growth suppressed, trashing excellent and very high fall of trash, leaves and leaf sheaths almost devoid of prickles and hairs which, with its good trashing, makes it easily cut and handled, arrowing variable from rather heavy (higher elevations in Barbados) to complete absence (parts of Trinidad); cane yields always high, ratooning excellent: milling quality very good, juice quality possibly the best of any Barbados seedling in commercial planting.

In Barbados, so far resistant to mosaic, gumming and root diseases,—in Jamaica, highly susceptible to mosaic, in Barbados, shows resistance to moth borer attack.

In Barbados, extensive results from trials will not be available until the 1942 crop but it is felt that it will suffer from lack of moisture in the lower rainfall areas (a phenomenon especially noticeable in early heavy tillering types) and from marked arrowing in the higher rainfall areas. In the former areas it is unlikely to equal B.37161 and in the latter it is doubtful if it will equal B.35245, B.35187 and B.37161. At best, the writer anticipates that it might have a limited use as an early cane throughout the island, thus displacing B.3439. For Jamaica, the results of the 1941 trials, in which B.34104 appears, are not yet to hand, but on the writer's visit at the end of 1940, it was quite obvious that in growth, B.34104 was outstanding, its only rival being B.3439. The situation, however, is complicated by the fact that B.34104 shows high susceptibility to mosaic in Jamaica. (Parenthetically, its susceptibility in Jamaica should be compared with its resistance in Barbados and the reverse reactions by B.3439 to the disease in both colonies may be noted). Recent information tends to indicate for Jamaica that its susceptibility seems to be associated with a high tolerance, but further conclusive information is awaited. At the moment, it might seem that in Jamaica B.34104 could serve as an early cane in both fertile and infertile areas where mosaic is not so virulent, B.3439 serving as the main crop cane in such areas and as the general standard in severe mosaic areas.

In Trinidad and Antigua, B.34104 has been fairly well tested. In Trinidad, unfortunately it has been directly compared with B.3439 on Ste. Madeleine clay only. Here, in one trial both varieties gave higher sugar yields than the standards, while in the other B.34104 outyielded the standard Co.213 with B.3439 closely following. Actually, there was little to choose between B.3439 and B.34104. In other trials (1941 series) in which it was tested and in which B.3439 did not appear, B.34104 was superior to all other varieties tested including the standards—B.H.10(12) and Co.213.

In Antigua, the situation is somewhat similar. That is to say, B.34104 and B.3439 rarely appear in the same trials, although each is superior in their own set of trials. They do appear together in two trials, in one of which there is nothing to choose between them although both are better than the standard Ba.11569, and in the other B.3439 outyields B.34104 and both outyield the standard—Ba.11569.

It would appear conclusive that both B.3439 and B.34104 are superior to standards and other seedlings tested over a wide range of soil and rainfall conditions, but no conclusive evidence is yet to hand to indicate which is better than the other and under what soil and rainfall conditions. Further experimental evidence is required to settle these doubts and in Trinidad, for the 1940/42 trials, no fewer than fourteen include both seedlings in addition to standards and other seedlings, and for the 1941/43 series nineteen trials are designed to include among others these two seedlings. A similar policy has been adopted in Antigua.

Of the less important seedlings under this head, B.3013 and B.3127 are both noble-canes which between them occupy about 10 per cent. of the cane growing acreage in Barbados. Both have been tested in Trinidad, St. Kitts and Antigua but, while B.3013 has shown some promise, it is inferior to B.3439. B.3127 has been disappointing. Both B.3013 and B.3127 are being replaced in Barbados by later seedlings while neither will become commercial canes in the other islands. The seedlings, B.3254, B.3172 and B.34110 are all nobilisations of Java glagah (*Saccharum spontaneum*). In Jamaica, they have shown high resistance to mosaic disease and otherwise reasonably promising growth. They are being tested in variety trials.

Seedlings so far Extensively Tested in Barbados only.

This second head concerns seedlings which have so far been extensively tested in Barbados only. The findings from these tests are given here and an attempt is made to give some indication as to the possible usefulness of the outstanding seedlings to the other colonies.

This head comprises seedlings of the B.35' and B.37' series. On account of a change in the technique of testing first year seedlings a delay of one year was involved, resulting in there being no first year seedlings reaped in 1936 and therefore no B.36' series.

Nineteen noble cane seedlings and twenty-nine nobilisations of the B.35' and B.37' series were despatched to the Plant Quarantine Station,

Of this number all noble cane seedlings and ten nobilisations were further tested in Barbados. The others will be further tested in Jamaica, Trinidad and Antigua.

These tests indicated that, while some of the noble cane seedlings gave promise of competing with the then existing standards — B.2935, B.726, B.H.10(12), B.3013, none had any chance of equalling, let alone bettering the nobilisations which have since emphatically outyielded these standards. It is extremely improbable that any noble cane seedlings of the B.35' or B.37' series will become commercial varieties in the contributing colonies.

Of the nobilisations tested, the following are outstanding—B.35187, B.35245, B.37161. These are described here.

B. 35187.

Its derivation in Barbados is as follows :—

P.O.J. 2725 × B.H. 10(12)

B.3172 × B.391

B.35187

Germination is excellent, growth habit at first recumbent, later semi-erect, tillering fairly heavy, cane growth with adequate moisture rapid but severely retarded where moisture is not adequate, canes above average in the stool and very thick and long; no arrowing, cane keeping quality very good; ratooning very strong, cane yields in heavier soils with higher rainfall very high: juice late in reaching its optimum but very high quality when ripe.

In Barbados no case of mosaic seen in spite of full exposure to the disease in test plots and commercial plantings, immune to gumming disease and resistant to root diseases.

This variety is suited as a late cane to high rainfall and to a lesser extent intermediate rainfall areas and as a late cane in valley soils. It must have a long favourable growing season to give its high tonnages and ripen its juice. In Barbados, it is being recommended to displace B.H.10(12) in red soil areas.

Outside Barbados, it is doubtful, on account of late ripening, if it will be of any use in Trinidad except as a late cane in the black marl soils of the Usine Ste. Madeleine. In Jamaica, if it shows commercial resistance to mosaic disease, it should serve as a late cane in good soil areas throughout and replace partly B.H.10(12) and, with B.3439, P.O.J.2878 in mosaic areas. In St. Kitts it should be tested as a late cane against B.H.10(12) in high rainfall areas and in Antigua it should be tested in better class soils as a late cane throughout the island.

B.35245.

Its parentage is as follows :—Ba.11569 × P.O.J.234. Germination very good, stooling and growth at first slow, later rapid; growth habit upright; canes very thick and long, arrowing scanty or absent, canes keep well during crop; ratooning exceptionally strong: cane yields especially ratoon yields very high in intermediate and high rainfall areas: juice quality excellent early in crop.

In Barbados, highly susceptible to mosaic disease and slightly susceptible to the leaf form of gumming disease, resistant to root diseases.

It is recommended in Barbados for commercial planting to replace B.726 *i.e.* as an early variety in the high and intermediate rainfall districts.

Outside of Barbados, it is expected that its marked susceptibility to mosaic will exclude it from Jamaica. In Trinidad and Antigua it should be tested under all soil conditions. In St. Kitts it should be tested in the intermediate and higher rainfall areas.

B.37161.

Its derivation in Barbados is as follows :—

P.O.J. 2379 × B.H. 10(12)

B.3365 ×B. 603

B. 37161

Germination excellent, tillering at first very slow and the bulk of the crop made up of mid and late season canes, cane growth exceptionally fast, canes medium to thick, arrowing rather marked at higher elevations, canes keep very well during crop: cane yields under all conditions exceptionally high, ratooning strong; juice purities very high early and throughout crop although brixes only average.

In Barbados so far resistant to mosaic and immune to gumming disease, resistant to root diseases: susceptible to small moth borer although damage does not tend to spread from larval channels in the canes.

This seedling has given outstanding yields under all conditions in Barbados outyielding the standards by 20 per cent. to 80 per cent. in sugar yields. It seems to have a special preference for heavy soils but can successfully withstand long periods of drought.

Outside of Barbados it should be tested in all colonies under all ecological conditions, but its usefulness in Jamaica will depend on how it reacts to mosaic disease and in Trinidad on how far it can compete with weed growth in the early stages of its growth when it tillers very slowly.

Certainly, in Barbados its yields are sensational and it is certain to do well in Antigua and St. Kitts.

Before leaving this section there is one seedling —B.37193—which was despatched to the Plant Quarantine Station but in Barbados reserved only as a parent for breeding and distributed as a fodder cane. Its parentage is the same as B.37161. In the breeding plots and when grown as a fodder cane, it looked so well that it has since been multiplied in Barbados for inclusion in more extensive trials during season 1941/43. In its only test in Barbados, the second year test with B.2935 as standard reaped in 1939, it gave approximately similar cane yields as B.2935 with appreciably better brix. It is a thin to medium width cane but is unusual in that it does not arrow, even in the breeding plots. It is possible that it may serve as a general purpose cane and it is recommended for tests in all ecological areas in the contributing colonies.

Outstanding Seedlings of Recent Origin.

Under this third head, brief reference is made to those among the seedlings of the B.38' and B.39' series despatched to the Plant Quarantine Station which were outstanding in the second season of test in Barbados.

In the B.38' series, fifteen nobilisations only were sent to the Plant Quarantine Station. The best of those in Barbados were—B.38209, B.38192, B.38233. The first noted was in the thick cane trial with B.2935 as standard, the two others were in the thin cane trial with Co.213 as standard. Their performances are noted in Table 1.

These three seedlings should be given special attention in multiplication and testing.

In the B.39' series twenty seedlings were selected and despatched to the Plant Quarantine Station and all are nobilisations.

Of this lot the outstanding seedling is B.39200, which, in its second season of test was compared with the standard B.2935. (*See* Table 2.)

This seedling, on account of an early tillering and squat habit of growth covers in early and for this reason, in addition to its good cane yield and juice quality and the fact that it has Co.213 in its parentage, promises to do well over a wide range of conditions.

Several other seedlings of this series did well in Barbados but none was so outstanding as the above.

Future Policy.

In future no more noble cane seedlings will be despatched for the simple reason that they are not so good as the nobilised seedlings.

Further, it seems that the second season's test in Barbados gives a reasonably accurate indication of the general value of seedlings for all contributing colonies so that in future, selection standards will be more strict with a likelihood of smaller numbers of seedlings being despatched. The exception at the moment to this policy is of course selection of seedlings for resistance to mosaic to serve Jamaica. Large numbers under this head will still be sent to give information on mosaic disease inheritance trends for Jamaica conditions in addition to increasing the chances of getting individual seedlings with mosaic resistance and otherwise good commercial characteristics.

Table 1.—*Thick Cane Trial*: *Reaped February*, 1940.

Variety.	Derivation.	Yield. Tons per acre.	Average No. Canes per plot.	Per cent. of Canes Arrowing.	Juice °Brix.
B.2935 ...	—	20.4	77	0	20.2
B.38209 ...	Ba.11569 × B.34116	24.6	106	0	21.5
	B.34116 = Co.281 × B.H.10(12)				
	Thin Cane Trial: *Reaped February*, 1940.				
Co.213 ...	—	30.5	210	45	19.0
B.38192 ...	MD.47 × Co.281	35.9	190	28	21.2
	(MD.47 = P.O.J. 2364 × B.606) ...				
B.38233 ...	P.O.J.213 × P.O.J.2878	41.8	193	10	21.2

Table 2.

Variety.	Derivation.	Yield. Tons per acre.	Average No. Canes per plot.	Per cent. of Canes Arrowing.	Juice °Brix.
B.2935 ...		24.5	103	0	20.4
B.39200	B.35206 × B.603 (B.35206 = Co.213 × B.391) ...	31.0	130	4	22.1

ASSESSMENT OF FERTILITY OF ABNORMAL SOILS: (B) FERRUGINOUS RED SOILS.

(Comparison of Chemical Tests with the Mitscherlich and other Pot Tests.)

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(I) Introduction.

This article follows a previous one‡ describing an investigation into the fertility status of a "humus-carbonate" soil or Rendzina, by means of chemical analysis and the application of the Mitscherlich pot test. The same procedures have now been applied to another peculiar kind of soil, frequently regarded as "abnormal," namely, a highly-ferruginous phosphate-fixing soil-type, a good example of which occurs within the Naparima District of South Trinidad. This soil is a red clay, derived from non-calcareous silt-stone of Miocene age which outcrops alongside the Princes Town Marl or parent rock of the Rendzina described in the first article.

(II) Description of the Soil Samples.

Two different samples of soil, taken from widely-separated sites, were examined.§ Both were surface soils to 10 inches depth, bright red in colour, comprising a highly acidic, phosphate-deficient phase of the Talparo Clay soil-type in E. M. Chenery's classification. They were procured respectively from Ben Lomond Estate (Field 38) and Hermitage Estate (Field 53), belonging to the Ste. Madeleine Sugar Company.

The red soils of the Ste. Madeleine area have been recently described by C. F. Charter‖ under the name *Ste. Madeleine Suite.* Included in them is the Ste. Madeleine Series, comprising red-coloured, very heavy clay soils developed "over greenish-grey and red-mottled parent material derived from brownish or greyish-green clay-shales". The profile shows little change in texture downwards. The content of clay varies between 80 and 85 per cent., and of silt, up to 10 per cent. The small amount of sand is mainly concretionary and ferruginous; it occurs solely in the upper part of the profile. The colour of the surface soil is bright (salmon) red, merging at a depth of 12 inches or more into pale-coloured, crimson or red-brown-mottled, siliceous clay. The reaction of the surface soil lies between pH_4 and pH_5; that of the parent mottled clay is around pH_4, becoming less acidic in the parent rock, which may even be alkaline in reaction because of included calcareous foraminifera.

The chief exchangeable bases in the red surface soil are calcium and magnesium which occur in about equal amounts. Exchangeable potassium is relatively abundant. Crystals of gypsum may be plentiful either in the soil, the parent clay or the parent rock.

During wet weather, the Ste. Madeleine red clay soils become water-logged because of their imperviousness which causes drainage impedence. The soil-type cannot be regarded as productive of sugar-cane; "noble" canes give poor yields; they grow slowly during the dry season and fail to ratoon satisfactorily. Uba and other thin-stemmed hardy varieties are almost exclusively grown on the red soils.

Chemical Features:—The analytical data for the samples are given in Table I.

According to present standards, both soils would be described as very highly acidic, non-calcareous, silty-clays, containing low but differing amounts of organic matter and nitrogen and with very low carbon-nitrogen ratios. Their contents of available phosphate are very low, and well below the limit of adequacy (put at 30 p.p.m. P_2O_5 for sugar cane). Their contents of available

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‡ This Journal, XVIII, 11, 1941, pp. 213-220.

§ The soil samples were collected by Mr. J. A. Potter, Sugar Agronomist of the Ste. Madeleine Sugar Company, to whom our thanks are due for this co-operation.

‖ A Preliminary Survey of Soil-Types of Sugar Estates of Trinidad. C. F. Charter. Sugar-Cane Investigation Committee, 1939, pp. 9-64. The account is taken mainly from Charter's description.

Table I.—Laboratory Soil Data.

Soil Sample.	Silt and clay.	Index of texture.	Reaction.	Org. matter.	Total (1) N.	C/N ratio.	Electrical conductivity. Avail. Nutr.	Electrical conductivity. Rate of Soln.	Avail. (2) P_2O_5.	Avail. (3) K_2O.
	%	I.T.	pH.	%	%		mhos. $\times 10^{-6}$		p.p.m.	
Ben Lomond (F.38)	83	32	4.6	1.5	0.15	6.1	108	1	12	137
Hermitage (F. 53)	93	46	4.7	2.1	0.17	7.4	172	25	7	137

(1) Kjeldahl's method.
(2) Truog's method; extracting agent, N/500 sulphuric acid.
(3) Exchangeable potash; extracting agent, N/2 acetic acid.

RESULTS OF MITSCHERLICH TEST APPLIED TO FERRUGINOUS RED SOIL.

(A) Ben Lomond Estate: Trinidad.

Fig. 1.—*Expt.* 1 (A).—Red ferruginous soil; whole soil, Unlimed. *Left to right:* i, ii. Lacking N; iii, iv. Lacking P; v, vi. Complete manure. Sudan Grass cultures, 3 weeks after sowing. (M. 1, 2, 5, 6, 7, 8).

Fig. 2.—*Expt.* 1 (B).—Red ferruginous soil; whole soil, Limed. *Left to right:* i, ii. Lacking N; iii, iv. Lacking P; v, vi. Complete manure. Sudan Grass cultures, 3 weeks old (M. 1, 2, 5, 6, 7, 8.)

(B) Hermitage Estate: Trinidad.

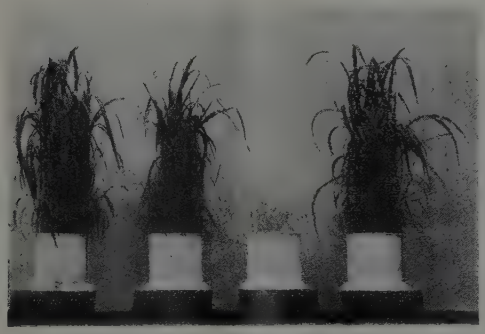

Fig. 3.—*Expt.* 2.—Red ferruginous soil; whole soil, Limed. *Left to right:* i, Lacking N; ii, Lacking K; iii, Lacking P; iv, Complete manure. Sudan Grass cultures, 3 weeks after sowing. (C. 1b, 4, 5, 9.)

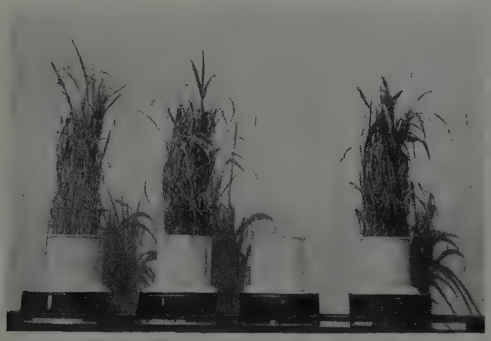

Fig. 4.—*Expt.*3—Red ferruginous soil; 1 soil: 2 sand, Limed. *Left to right*: i. Lacking N; ii. Lacking K; iii. Lacking P; iv. Complete manure. Sudan Grass cultures, 3 weeks after sowing. (D. 1c, 4, 6, 10.)

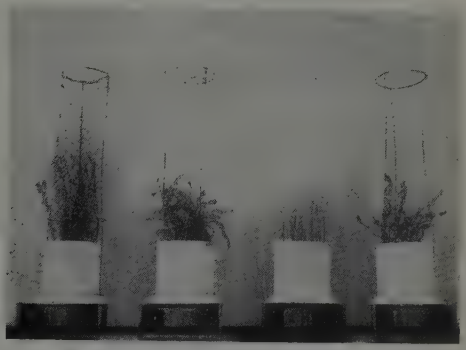

Fig. 5.—*Expt.* 4.—Red ferruginous soil; 1 soil: 2 sand, Limed. *Left to right*: i. Lacking N; ii. Lacking K, iii. Lacking P; iv. Complete manure. Linseed cultures, 3 weeks after sowing. (E. 1b, 4, 7, 8.)

potash are medium-low, and somewhat below the limit of adequacy (put at 150 p.p.m. K_2O). The base exchange capacity in each case is only partially satisfied by calcium, to the extent of about 14 per cent., and exchangeable magnesium is almost equal in amount (*i.e.* 2.9 mg. equiv. per cent. for each base). The lime requirement for complete saturation by exchangeable calcium, calculated from the exchangeable base data, is about 7 tons of pure calcium carbonate per acre 10-inches depth of soil.

The samples comprise a somewhat extreme phase of Talparo Clay of the kind occurring in the Naparima District, in that they represent the upper part of *truncated* profiles, that is, profiles that have lost, by surface erosion, much of their original humic layer (Ao-A1 horizon), so that they are now very deficient in available phosphate and nitrogen, as well as excessively acidic and lime-deficient.

(III) Experimental Procedure.

Straight Mitscherlich tests were run on each soil sample for assessing the phosphate and potash status, and on the second sample for assessing nitrogen status. The soils were known to be capable of fixing large amounts of phosphate, so that, in accordance with Hawaiian practice, the standard dressing of phosphate manure was tripled. The treatments comprised (1) Lacking nitrogen (3PK): (2) Lacking potash (N3P): (3) Lacking phosphate (NK), and (4) Complete manure (N3PK) Each treatment was triplicated, 12 pots being used in a full test. A small quantity of a minor element solution was added to each culture.

Sudan Grass (*Andropogon sorghum* var. *sudanense*) was used as test plant for both soils, and also Linseed (*Linum usitatissimum*) was tried in the case of the Hermitage soil sample. The whole soil alone was tested in the case of the Ben Lomond sample, and the whole soil as well as soil diluted with quartz sand (1 part soil to 3 parts sand) in the case of the Hermitage sample. Initial trial of the Ben Lomond* whole soil sown with Sudan Grass gave satisfactory though tardy germination, but within three weeks, all the seedlings had turned yellow and died, not having advanced beyond the third leaf stage, and no adventitious roots had developed. Accordingly, the soil was allowed to dry out and removed from the pots. Each culture was then thoroughly mixed with calcium carbonate in amount sufficient to satisfy the full lime requirement, and returned to its pot. The pots were then resown with Sudan Grass. The new seedlings now grew normally, with the exception of those that had received no phosphate (*see* photographs). An attack of Thrips retarded the growth at a late stage, necessitating spraying with nicotine sulphate solution, which effected good control.

* The preliminary trials and the Mitscherlich test on Ben Lomond Soil were run by A. S. Harper.

The same procedure was afterwards followed in each of the other tests,* the soils being fully limed before adding the manures. The yield data obtained are brought together in Table II, and the results of the Mitscherlich calculations are given in Table III. Roots were not collected. The times of sowing and reaping were as follows :—

Sample	*Culture*	*Test-plant*	*Date of Sowing*	*Date of Reaping*
Ben Lomond	Whole Soil	Sudan Grass	14th Sept.	7th Dec., 1940.
Hermitage	Whole Soil	do.	22nd May	4th Sept., 1941.
Do.	1 soil : 3 sand	do.	do.	do.
Do.	1 soil : 3 sand	Linseed	do.	do.

(IV) Discussion of Results.

Scrutiny of Table II shows that the yields of Sudan Grass for the "lacking potash" cultures were nearly the same for the whole soil as for the soil : sand mixture in the case of the Hermitage sample, but that the yield for the Ben Lomond sample was much less than either of these. The first result implies that neither soil is seriously deficient in potash; the second result may be partly explained by the facts that the crops were grown at different times of the year when the length of day was different, and that the seed used in the Ben Lomond test was an older sample which had been stored before use.

The calculated nutrient values agree well with the results of chemical tests (Table I), in so far as they show that the two soil samples are extremely deficient in available phosphate, but almost adequately supplied with available potash. The Hermitage sample proved also to be deficient in available nitrogen. The following facts have been established.

Nitrogen.—The amount of available nitrogen in the Hermitage soil, as calculated from the Mitscherlich results, is about 150 p.p.m., while its content of total nitrogen is 0.17 per cent. (1700 p.p.m.). Evidently, therefore, less than 9 per cent. of its nitrogen content is available for supporting the growth of Sudan Grass. In the case of Linseed, the available nitrogen status of the soil appears to be in excess of the plant's requirement.

The magnitude of the dressing of nitrogenous manure required for high yield of Sudan Grass and probably also for other gramineous crops, such as sugar cane, seems to be around 10 cwt. of sulphate of ammonia per acre for this red soil.

Phosphate.—The available phosphate content of each soil sample is negligible, as proved by all the cultures lacking phosphate. If it be assumed that the soil contains appreciable amounts of

* The tests on Hermitage soil were all run by E. G. Cripps.

Table II.—Experimental Results

Soils previously limed

Pot number	1 Treatment		2 No. of plants per pot	3 Average total weight of stems (*g*)	4 Corrected weight of stems (*g*)	5 Percentage of experimental maximum
		Ben Lomond Soil				
Experiment 1.—Whole Soil ; Sudan Grass						
M 1, 2, 3	N.3P	Lacking potash	24	40.5	40.5	96.0
M 4, 5, 6	N.K	Lacking phosphate	2	0.4	0.4	0.9
M 7, 8, 9	N.3P.K	Complete	23	42.2	42.2	(100)
		Hermitage Soil				
Experiment 2.—Whole soil ; Sudan Grass						
C 1 a, b, c	3P.K	Lacking nitrogen	35	66.2	66.2	68.1
C 2, 3, 4	N.3P	Lacking potash	35	82.1	82.1	84.5
C 5, 6, 7	N.K	Lacking phosphate	33	0.4	0.4	0.4
C 8, 9, 10	N.3P.K	Complete	35	97.2	97.2	(100)
Experiment 3.—1 soil : 3 sand ; Sudan Grass					(×4.0)	
D 1 a, b, c	3PK.	Lacking nitrogen	35	30.5	122.1	35.5
D 2, 3, 4	N.3P	Lacking potash	35	73.8	295.1	85.9
D 5, 6, 7	N.K	Lacking phosphate	32	1.0	4.1	1.2
D 8, 9, 10	N.3P.K	Complete	35	85.9	343.6	(100)
Experiment 4.—1 soil : 3 sand ; Linseed.					(×4.0)	
E 1a, b, c	3P.K	Lacking nitrogen	35	7.5	29.9	157.7
E 2, 3, 4	N.3P	Lacking potash	35	7.3	29.1	153.5
E 5, 6, 7	N.K	Lacking phosphate ...	34	0.9	3.8	20.0
E 8, 9, 10	N.3P.K	Complete	33	4.7	18.9	(100)

Table III: Nutrient Status and Manurial Requirement

(Calculated from Experimental Data)
Soils previously limed

Nutrient.	Nutrient Content				Manurial Requirement	
	Calculated from Mitscherlich data		Expressed as p.p.m. surface 6 ins.	Determined by chemical analysis	Calculated from Mitscherlich data	
	Whole Soil	Soil : sand :: 1 : 3*			Nutrients	Standard manures
	Cwt. per acre		Parts per million		Cwt. per acre	
			Ben Lomond Soil: (*Sudan Grass*)			
			Whole Soil			
Nitrogen (N)	—	—	—	—	—	—
Phosphate (P_2O_5)	0.01	—	0.1	12	1.74	Super. 9.7
Potash (K_2O)	1.20	—	67	137	0.40	S/Pot. 0.8
			Hermitage Soil: (*Sudan Grass*)			
			Whole Soil			
Nitrogen (N)	2.35	—	132	—	2.45	S/A. 12.2
Phosphate (P_2O_5)	0.002	—	0.1	7	1.75	Super. 9.7
Potash (K_2O)	0.69	—	39	137	0.91	S/Pot. 1.8
			Soil : Sand : : 1 : 3.			
Nitrogen (N)	—	3.25*	182	—	1.55	S/A. 7.7
Phosphate (P_2O_5)	—	0.028	1.6	7	1.72	Super. 9.6
Potash (K_2O)	—	2.91	163	137	nil	S/Pot. nil
			(*Linseed*)			
			Soil : Sand : : 1 : 3.			
Nitrogen (N)	—	Excessive	—	—	nil	S/A. nil
Phosphate (P_2O_5)	—	0.520	29	7	1.23	Super. 7.0
Potash (K_2O)	—	Excessive	—	137	nil	S/Pot. nil

* Values corrected for degree of dilution by added sand.

total phosphate, then evidently nearly all of it is firmly fixed* (presumably as insoluble iron phosphate), so that both Truog's reagent (N/500 sulphuric acid solution) and Sudan Grass plants (though to a lesser extent Linseed plants) are unable to extract more than a trace of phosphate. It should be remembered that, unless and until the soil is thoroughly *limed*, added phosphate manure fails to produce response in the test plants, an effect which may be explained either by postulating the formation of easily-soluble calcium phosphates, or by assuming that phosphate fixation by active hydrous ferric oxide only takes place under highly acidic conditions.

The magnitude of the dressing of phosphatic manure needed for high yields of Sudan Grass, and perhaps also of sugar cane grown on this kind of soil, is apparently nearly 10 cwt. of superphosphate per acre, though considerably less for Linseed. It might be noted, however, that there are phases of the Talparo Clay soil-type occurring in various parts of the Ste. Madeleine area in which the content of available phosphate is considerably greater than that of the two samples examined; indeed the application of Truog's chemical test to a wide range of samples of the soil-type has revealed some having available phosphate contents well above the value at present accepted for adequacy, that is, above 30 p.p.m. P_2O_5 in the surface 6-ins. of soil.

Potash.—The available potash content of each soil sample would appear from the results of the Mitscherlich test to be relatively high, agreeing with the chemical test which showed nearly adequate values (135 p.p.m.; adequacy taken as 150 p.p.m. K_2O). The standard set up by P. E. Turner for non-calcareous sugar-cane soils in Trinidad† is less than ours, namely, 90 p.p.m., and on this standard both soils would be regarded as well supplied with available potash.‡ It might be noted also that the soil : sand cultures with Hermitage soil showed no potash shortage, neither for Sudan Grass nor for Linseed. Statistical analysis of the yield data for Sudan Grass cultures with Hermitage soil demonstrated that the difference between the mean yields of the "lacking potash" and the "complete" treatments is not significant. The soil would therefore be regarded as near the border-line of potash deficiency, and the magnitude of the dressing of potash manure needed for maximum crops is probably small, say around 1 cwt. sulphate of potash per acre, or less.

There seems here to be no abnormality in the behaviour of these two samples of red soil towards the accepted chemical tests for available phosphate and for available potash.

Note on Linseed as test-plant.—The Linseed used as dicotyledenous test-plant was an ordinary farm sample not specially selected. The results it gave differed considerably from those that were given by Sudan Grass, and indicate that its requirements of nitrogen and potash are not so great. Since the chief interest of these tests lies in their suitability for assessing the Ste. Madeleine red soils for sugar cane growing, the choice of Sudan Grass rather than Linseed as test-plant is preferable.

The prime need of this Ben Lomond Red Soil and soils of the same kind thus appears to be *lime and phosphate*; furthermore, both liming and the application of artificial phosphatic manure seem to be necessary for high yields, even when heavy dressings of organic manure are also applied. In this respect, pen manures, dung, composts, and similar low-grade organic manures may prove inadequate, because of their "unbalanced" chemical composition, when applied alone to certain phases of the Ste. Madeleine red soil, although some types of filter-press mud, known to be especially rich in phosphate, as well as the common concentrated organic manures (oil-seed and meat meals, dried blood, &c.) might satisfy nutrient requirements if applied in sufficient amount along with the necessary quantity of lime.

(V) Comparison of Results with Estate Manurial Practice and Experience.

The response to manuring shown by the Ste. Madeleine Red Soils growing sugar cane has been investigated since 1928 by numerous field experiments laid down on the modern Latin Square plan, with statistical treatment of results, under the charge and direction of J. A. Potter (Ste. Madeleine Sugar Company), in collaboration with P. E. Turner (Trinidad Department of Agriculture; Agronomist to the Sugar-Cane Investigation Committee). The following summary of results has been taken from the latest annual report* on these experiments, as well as from previous annual reports and articles† compiled by P. E. Turner during the past eight years.

* The actual phosphate-fixing abilities of these two red soils, as determined by the method used in Hawaii, are 0.314 and 0.288 per cent. P_2O_5, which are equivalent to 310 and 285 *cwt.* of superphosphate per acre 6-inches of soil!

† Field Experiments on Sugar-Cane in Trinidad; Annual Report for 1940; P. E. Turner; Trinidad Dept. Agric. Sugar-Cane Investigation Committee Publication, March, 1941, p. 243.

‡ The soil had been limed in this test, and the liming may have increased the quantity of available potash above the amount originally gauged by the chemical test.

* Field Experiments on Sugar Cane in Trinidad; *Annual Reports* for 1940, 1939, 1938, 1937; P. E. Turner; Published by the Sugar-Cane Investigation Committee.

† (*a*) Manurial Experiments with Sugar Cane; No. IV; P. E. Turner and J. A. Potter; *Tropical Agriculture*, 1932, IV, pp. 44-53. *Ditto*; No. VI; P. E. Turner, *Ibid.*, 1933, X, pp. 60-67.

(*b*) Recent Investigations on Sugar Cane and Sugar-Cane Soils in Trinidad; No. I; P. E. Turner; *Trop. Agriculture*, 1935, XII, pp. 262-268. No. II; *Ibid.*, XII, p.p. 293-302 and pp. 320-332. No. III; *Ibid.*, 1936, XIII, pp. 299-306 and pp. 319-326; 1937, XIV, pp. 63-69.

Effect of Liming.—A large-scale liming experiment, designed to test the effects of liming with and without pen-manuring on the yield of B.H. 10(12) sugar cane, was laid down in 1929 on Ste. Madeleine Red Clay Soil, and was continued until 1938. The results showed conclusively that liming alone was highly beneficial, while pen-manuring gave additional large increases up to nearly twice the magnitude of the untreated crop. Because of this discovery, a policy of applying ground limestone up to 5 tons per acre to all red-soil fields showing high lime requirements has been adopted.* This has resulted in all-round increases in yield of plant-canes of 5 to 8 tons per acre.*

Effect of Sulphate of Ammonia.—Applied alone in graded dosages over eight successive crops of Uba cane growing in Red Clay Soil lacking humus, this manure has given increments up to 80 per cent. of the initial yield of the unmanured soil. So far, no signs have been detected of diminishing beneficial effects of the continued application, though a dressing of 5 tons per acre of ground limestone was applied half-way through this particular experiment. As outcome of this and other experiments, a policy of applying sulphate of ammonia in 3 cwt. per acre dressings to Uba cane growing in this type of soil has been adopted as optimum.*

Effect of Phosphate.—When applied to Red Clay Soil containing around 23 p.p.m. available phosphate (P_2O_5; Truog's test), comparatively small dressings of superphosphate have been usually found to give beneficial effects. The response to phosphate manure has been shown partly to depend, however, on the lime, nitrogen and potash status of the treated soils. On one area where the soil was deficient in both available phosphate and potash, according to established laboratory standards, superphosphate gave a distinctly beneficial effect on Uba cane, and the benefit was independent of potash at one level of nitrogen manure, but was greatest when potash was supplied in addition at a higher level of nitrogen. On another area where the soil was deficient in available phosphate but not in available potash, superphosphate gave increased yields with and without potash supplied in addition. The effect here was independent of the magnitude of the dressing of nitrogen manure. On a third area, deficient in phosphate but on the border-line for potash, superphosphate gave a large increase in yield of Uba plant-cane.

It would thus appear that comparatively small dressings of phosphate manure (2 cwt. ac. of superphosphate) will give beneficial results on these three areas of phosphate-deficient red soil, apparently without previously liming, so that little fixation of phosphate can have occurred therein.

* J. A. Potter, private communication.

Effect of Potash.—In general, the response to potash manure applied to the Ste. Madeleine Red Clay Soil has been proved to vary inversely with the exchangeable potash content of the soil, provided this is less than 90 p.p.m., which is regarded as denoting the lower limit of potash adequacy in this soil-type.

(VI) Conclusions.

It might confidently be predicted that sugar canes growing in the Ste. Madeleine Red Clay Soil would respond to dressings of lime, phosphate assimilable nitrogen and potash, *in that order*, wherever the soil may prove on chemical analysis to be acidic and lime-deficient, lacking available phosphate (below about 30 p.p.m. P_2O_5, Truog's test), and lacking available potash (below about 90 p.p.m. K_2O, exchangeable potash). On the other hand, phases of the soil which contain more than adequate amounts of available phosphate and potash by chemical tests may respond directly to suitable dressings of nitrogenous manures alone, provided their lime requirement is not excessively high. Whether or no the treatments would be profitable or economical under prevailing costs of labour and manures may only be determined by elaborate field experimentation.

The magnitudes of manurial dressings needed for optimum yields have indeed already been mostly worked out. It is submitted, however, that the accumulated knowledge now available from chemical tests, pot tests, manurial experiments and general estate experience, indicates that future field investigations of the Ste. Madeleine Red Clay soil -type should take into account the interactions between *all* the factors considered in their various soil and plant relationships, unless it has definitely been established for any particular experiment that any one of them is not likely to operate in limiting sugar cane growth.

TERMITES AND SOIL FERTILITY.

While the destructive rôle of termites in the tropics is widely recognized, another aspect of their activities has so far attracted little attention, namely, their effect on the physical and chemical properties of the soil, which they are known to influence to a great extent. Preliminary investigations carried out in Nigeria (*Nigerian Forester*, 1, 8; 1940) have shown that the soil of an active termite heap contained an increased amount of fine particles, which tended to improve the water-holding capacity of the soil. The carbon content of a heap, was six times, nitrogen content about five times, phosphorus content two-and-a-half times, and potash content more than three times that of the normal soil. Bearing in mind the wide spread of termites in Africa and the enormous extent of their underground activities, the problem deserves a very serious study from the points of view of termite bionomics, soils, natural vegetation, crops and forestry.—(*Nature*; No. 3750, 1941, p. 318.)

THE BANANA TRADE FROM THE WEST INDIES TO CANADA.

By E. R. Leonard.
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Introduction.

The Low Temperature Research Station, Trinidad, is at present engaged in research on the metabolism of the banana and in particular is investigating the possibility of extending the storage period of bananas from the West Indies and of improving the quality of the final ripe fruit. A knowledge of existing commercial practices in the production, transport and distribution of bananas is therefore essential. Cultivation methods in the Caribbean area (3) and shipboard conditions (2) have been described recently. The following account outlines the present day methods of transport, ripening and distribution of bananas in the trade between the British West Indies and Canada, and was compiled from data obtained on a visit to the Dominion in 1940.

Organization.

The wholesale distribution of bananas in Canada is based on St. John, N.B. and Halifax, N.S. for the Maritimes; Montreal for Montreal itself, Quebec and Toronto and districts; Winnipeg is the centre for the prairie provinces, receiving its fruit from New Orleans by rail, whilst Vancouver distributes fruit from Costa Rica and Panama to British Columbia, Alberta, and sometimes Saskatchewan.

Ocean Transport.

The trade was started from the Eastern Group of the B.W.I. in 1933 by Canadian National steamships, replacing the service previously carried on from Dominica and St. Lucia by the Leyland line and from Trinidad by the Elders and Fyffes line to the United Kingdom and, under normal conditions, is maintained by three boats at fortnightly intervals, loading at Trinidad, Grenada, St. Vincent, St. Lucia, and Dominica for discharge at St. John or Halifax. A service from Jamaica was started some years before by the same company and maintained by four boats discharging at Montreal during the summer months. The fruit is shipped under contract with the United Fruit Company, through a subsidiary, the Canadian Banana Co.

The voyage from Trinidad to St. John normally occupies twelve days and from the other islands, Grenada and St. Vincent eleven, St. Lucia nine and Dominica eight days. An additional 21 hours is occupied in transport by rail from St. John to Montreal for such fruit as is forwarded in this way, giving a total time for Trinidad-grown fruit between cutting (allowing 24 hours between cutting and delivery on shipboard) and receipt at the more distant wholesalers of 14 to 15 days. Nevertheless the grade of fruit normally specified by the contracting company is "Full ¾"* and not the "¾-Full"* previously found suitable for an equal length of voyage to the United Kingdom.

Considerable differences in the quality† and condition† of the bananas from the different islands are apparent at the time of loading and these are further emphasised at the time of discharge. The differences in quality are apparent in the "count number",* in the grade which each island has found by experience is suitable for shipment, in the firmness or laxity of the bunch stem, in the skin colouration and in other readily perceptible factors less susceptible of definition.

A description of the loading procedure and of the rates of cooling and gas concentrations in the holds has been given previously (2). An air temperature of 53° F. is maintained in the holds by delivering refrigerated or, in the winter months in more northerly latitudes, heated brine to the battery-system coolers. As already noted (2) no inspection of the condition of the fruit is possible until the day prior to arrival at the first Canadian port, when the several chambers are opened, the general condition of the fruit examined and flesh temperatures taken. The considerably longer storage period necessary with the fruit from the more southerly islands, due to the two days diversion to Barbados, reflects markedly on the condition of fruit from these islands, Trinidad fruit in particular suffering from slight to considerable "chilling."

Discharge takes place immediately on arrival at St. John and the fruit is divided according to the demands of the different wholesalers in the Maritime provinces and Quebec and Ontario. The wholesalers specify the condition of ripeness of the fruit they require. Allowance is made for price adjustment above or below standard according to the quality and condition. "Special" bunches are cut up into hands, yellow-ripe or green, and boxed with paper shavings in corrugated cardboard containers of 45 to 55 lbs. for local St. John or Montreal markets.

The trade based on Vancouver is less specialized, shipments being simply sorted into carloads irrespective of stage of ripening.

Discharge from the chambers is into padded tubs on wheels lowered into the hatch space, hoisted ashore and wheeled to freight cars. In winter each tub is covered with an insulating blanket and discharge is to a heated shed. Air temperatures of 0°F. are common in Eastern Canada.

* An explanation of the terms is given in (7).

† "Quality" concerns those characters due to growth factors, "condition" those due to handling, *e.g.* splitting of stems, bruising of hands.

Railway Transport.

The freight cars are of two types. The majority are the Basket Bunker Ventilator type with an ice bunker at each end and floor-racks. In summer sufficient ice (usually 750 lbs. to 1,500 lbs. per bunker) is loaded into the bunkers and re-iced every 12 to 18 hours during transit, as necessary. Ventilators are left open at the rear end to provide a through draft. A travelling messenger accompanies the fruit freight train to check temperatures.

The capacity of the cars is 75,000 lbs. but they are loaded only to 20,000 lbs. which constitutes the minimal paying load. With count* bunches the loading is one standing and one riding: with "eights"* or less, one standing and two tiers riding, butts of top tiers to walls, top hand of riding bunches up. A 2 to 3 foot centre alley is left for inspection of temperatures and this is dunnaged off with slats nailed together. A larger alley is left if boxed hands are to be loaded.

Temperatures are maintained at 53-68°F and are observed by means of thermometers in the alley, 2 feet up, *i.e.* about the centre of the pack.

During winter the cars are preheated to 100°F. by an oil heater for twelve hours prior to loading and charcoal burners are provided in the end bunkers during transit.

In an improved type of car recently introduced (4) an overhead ice bunker is used or an underslung charcoal heater.

On arrival at Montreal the bananas are unloaded from the cars by the wholesalers. The Company's responsibility ends once the fruit is loaded into the freight car.

Distribution from Vancouver is made in smaller consignments than in Eastern Canada, by individual cars to Edmonton and Calgary; most of the trade is restricted to Vancouver and Victoria. No precautions are necessary for winter handling at the dock, air temperatures not falling below freezing point. Transport to the prairies is effected in Bunker Basket Ventilator cars, iced when necessary, but usually loaded in the evening and carried overnight through the mountains. No difficulty is experienced in making up the necessary 20,000 lb. carload with a single standing and one riding bunch, due to the high percentage count and the heavy bunches, the grade being almost exactly "$\frac{3}{4}$-Full."

Ripening Rooms.

The banana rooms in Montreal are in general poor. The older type are mostly basement rooms with a fan and arrangements for drawing air from the cooler part of the building. In summer, refrigeration to give temperatures below 70° F. (which is desirable to avoid "boiled" bananas) would be necessary for only a short period and it is probable that this can be achieved by arranging the time of ventilation. Some wholesalers make an attempt to lower the temperature by placing blocks of ice in the middle of the floor of a room but it is very doubtful if this is at all effective.

In winter, heating to the desired temperature (62-64° F.) is achieved by gas or electricity. In some instances an attempt at humidity control is made by means of electric immersion heaters in a bucket of water but no humidity measurements are made. Reversible fans for stirring up or extracting the air are provided in the better type rooms but their capacity and that of the ducts appears inadequate for effective ventilation.

In Vancouver similar rooms of the poorer class exist but also completely modern, battery-system refrigerated rooms with thermostat control and steam humidifiers. The poor type rooms are uninsulated and unventilated (Vancouver winter conditions are much less severe than Montreal), the temperature being raised by means of gas rings when necessary and humidity by sprinkling water on the floor or wrapping the bunches in wet sacks. The final condition of the fruit from the well-equipped rooms is considerably better and the flexibility of ripening control is obviously greater.

Personal Observations.

From personal observation of a single shipment of bananas from the Eastern Group of the B.W.I. during stowage and on discharge at St. John it was obvious that there is considerable room for improvement in the quality and condition of the fruit.

Dealing first with the bananas from the different islands, those from Trinidad must be ranked lowest. On discharge the stems were considerably more lax than those from other islands: there was considerable spotting (due to thrips?) and the grade was somewhat below "Full $\frac{3}{4}$"; stem end rot was slight. Grenada fruit is reported to show more "stem-end rot" (finger stalk rot) than other islands. This may be a seasonal effect. The grade was uniform "heavy $\frac{3}{4}$-Full" as was the St. Vincent fruit. From St. Lucia the bunches showed a range from "$\frac{3}{4}$-Full" to "heavy $\frac{3}{4}$-Full" whilst Dominica was rated about the best consignment.

A considerable amount of fruit from the three southerly islands showed definite signs of the pink flesh colouration associated with Cercospora leaf spot disease (5) (7) and these bunches invariably were ripening. A further percentage of fruit also showed ripening apparently not associated with leaf spot disease. As assessed by the Canadian Banana Company officials in the consignment inspected, that from Grenada had 10-12 per cent. ripe, from St. Vincent 8 per cent. ripe, the criterion of ripeness being a considerable amount of yellow skin colour and the "sprung" condition. As judged by the earlier indication, the first trace of skin colouration, which

* An explanation of the terms is given in (7).

marks an early stage in ripening and that at which "chilling" may readily be induced, the number of ripening bunches was considerably greater (up to 50 per cent.) and slight symptoms of chilling were evident in the dull yellow colour of the skin.

It should be noted that this particular consignment had been subjected to a voyage period two days beyond the normal. Nevertheless it must be concluded that this grade of fruit, particularly from the more southerly islands of the Eastern Group, is very liable to "chilling" with inevitable loss of quality and digestibility when ripe (1) (7), especially when the ripening is premature due to the effects of Cercospora disease or other causes. The margin of safety in the transport of the "Full ¾" grade of fruit to Canada must be regarded as very small. In general, ripe fruit seen throughout Canada was of poor colour with considerable bruising and definitely below the standard of clear yellow-skinned bananas as retailed in England or as obtained with Trinidad fruit given a storage period at 53° F. suitable to its grade, followed by ripening under controlled conditions. Tolerance of "chilled" bananas has been observed in tasting trials on experimental fruit in Trinidad. Assessors recently arrived from the United Kingdom would accept fruit considered unpalatable by local born or residents of considerable duration.

The distances between ports and marketing centres in Canada are, of course, greater than in England. Nevertheless, provided fruit is landed green and firm the final appearance when ripe should not show such great differences.

With regard to wastage, this was very slight on discharge at St. John. No data were collected on the wastage in commercial retail distribution but it is obvious that a reduction in the state of ripeness of the fruit on landing would make for a reduction in wastage since green fruit is more readily handled without bruising and subsequent rotting.

The obvious remedy for the avoidance of "chilling" by lowering the grade of fruit cut (7) (8), especially from the more distant islands, was said to be inapplicable as it would be impossible to make up the necessary 20,000 lb. car load without increasing the depth of storage and thereby crushing the lower bunches.* The provision of racks for the uppermost tier of bunches was suggested, but these could not be permanently installed as the Bunker Basket Ventilator cars are the property of the railways and are used for other produce than bananas.

The only alternative is to improve the storage conditions so that the fruit can be landed in a less ripe condition. It is doubtful if this can be achieved by any reduction in the time between fruit-cut and attainment of the cold storage temperature. (i) Considerable delay is known to occur in some of the islands between cutting and arrival on shipboard due to poor communications between the plantations and the port of loading but it is doubtful if the trade warrants much expenditure on improvements. (ii) The time occupied in removing the field heat from the fruit and in reaching the storage temperature has been reduced to a very small proportion of that once considered essential if "chilling" was to be avoided (2), and any further reduction would very greatly increase the refrigeration cost. (ii) It would thus appear that some method of reducing the ripening trend in cold storage is essential. Two lines of approach are being explored at this Station, the application of various "waxing" treatments to the green fruit before storage and the use of "gas storage". Progress in the former has reached the stage of a confidential report and the latter has received preliminary publicity in a memoir, (6). Both these methods offer considerable hope of improving the condition of West Indian bananas in Canada.

A considerable improvement in the condition of the fruit on discharge is essential before any large outlay on improvement of the ripening rooms will be justified; nevertheless the better type of room can turn out bananas of considerably more pleasing appearance, and is obviously of use for the storage of other fruit.

* As a temporary war-time measure to allow for prolonged and variable voyage periods, the grade of fruit, from Trinidad at least, has been lowered to "¾-Full."

Acknowledgments.

The data incorporated in the above report were obtained by permission of the Canadian National Steamship Company and the Canadian Banana Company and grateful acknowledgment is made for facilities afforded, for helpful cooperation of the officers of these two companies, and for reading and correcting the typescript.

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ASPECTS OF PROGRESS IN THE STUDY OF PLANT NUTRITION.*

DURING the past twenty years, convincing evidence has been obtained that additional chemical elements must be added to the classical list of ten essential elements for higher plants. Boron, manganese, copper and zinc are needed for growth in minute amounts, according to results of investigations on many species of plants and recent experiments indicate that molybdenum must also be added to the list. There is reason to believe that silicon and other elements require further study from the point of view of essentiality. On the practical side, within the past decade, numerous studies have clearly established the agricultural significance of boron, manganese, copper and zinc, in explaining previously obscure plant diseases, such as little-leaf, mottle leaf, exanthema, and drought-spot in fruit trees, crack-stem in celery and heart-rot in sugar beets.

The functions of many essential elements in plant growth are still but dimly apprehended but a notable advance with respect to *phosphorus* is the achievement of the synthesis of starch *in vitro* from a phosphate ester of glucose with the aid of enzyme systems (4). General research in bio-chemistry has also provided fundamental knowledge of the rôle of phosphate in biological oxidation-reduction systems. This is likewise true of iron, and to some degree of copper and manganese. Magnesium also has a rôle in these systems. The place of zinc is not yet clearly indicated, but interesting relations of this element to certain phases of plant metabolism have been disclosed. The time seems to have arrived for a further intensive study of oxidation-reduction systems of higher plants, based on the developments of recent years so largely resting on studies with animal tissues and yeast cells (3).

Use of Isotopes in Research on Plants:—As a by-product of the researches of physicists on radioactive isotopes, it now becomes possible to follow the movement of chemical elements in plants, and to elucidate some of the chemical reactions involved in metabolism by a totally new and highly fruitful technique. Especially significant is the new approach in the field of research of photosynthesis (6). Not only radioactive isotopes, but also heavy isotopes can be employed in the study of metabolic processes, and the latter have particular value for experimentation when elements are concerned of which the radioactive isotopes available possess only a very short half-life, *e.g.* nitrogen. Despite the present great activity in this field of research, there is every reason to believe that the use of isotopes will occupy for many years to come a prominent place among the methods of attack on problems of plant and animal nutrition.

Organic Metabolism of Plants: — Animal biochemists have frequently made a much more intensive study of their metabolic systems than have the students of higher plants. Often the latter lean heavily on the experimental results the theories, and the hypotheses of the former. Yet several laboratories engaged in investigations of the metabolism of higher plants have reported extensive data, particularly in relation to the metabolism of nitrogen compounds and organic acids (1). It has become evident that these acids, including the keto-acids, are of far more importance in plant metabolism (especially with reference to respiratory processes and protein synthesis) than has been appreciated in the past. There remains the task of determining more completely and accurately individual components of the organic acid systems, and of assessing the significance of various cycles of transformation that have been tentatively proposed, to a considerable extent on the basis of previous studies on animal tissues. It is greatly to be desired that increased attention be given to experiments on these organic acid systems as they operate in green plants.

Absorption and Accumulation to Inorganic Solutes:—There seems to be a fairly general recognition of the necessity for explaining solute accumulation (movement against gradients) in terms of cell metabolism, but the mechanisms involved are still obscure, and theories or hypotheses are often in sharp conflict. The way in which energy is utilized in cellular processes remains one of the largely unsolved problems of biology. There are, however, certain biochemical events occurring during solute accumulation by plant cells which have been given intensive study. For example, in experiments on potato-tuber tissues the absorption of potassium leads to increased protein synthesis (7), and with active root tissues, a relation is found between differential cation and anion absorption and synthesis or oxidation of organic acids. Further exploration of this field is indicated as an indispensable objective for an understanding of plant nutrition (2).

Soil Solution:—Prevailing theories usually assume that the immediate source of plant nutrients in the soil is the soil solution. To a large extent this must be so, but recent work suggests an additional mechanism. It appears that ions may move directly from the soil colloids to the root by virtue of a process of ion exchange within the oscillation volumes of adsorbed ions (5). In these and other investigations of ion adsorption by roots, the radioactive isotopes already mentioned have served as an important tool of research.

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* Adapted from article by D. R. Hoagland in *Chronica Botanica*, Vol. 6, No. 15, 1941, pp. 345-364.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Vitamin-C Content of Fresh, Canned and Dried Guavas.*

The common guava, *Psidium guajava*, has not as yet received the recognition which it deserves as a potent source of ascorbic acid (Vitamin-C). Both in Hawaii and in India, values as high as 300 mg. per 100 g. have been reported for the fresh fruit, although many lower values are to be found in the literature. The Vitamin-C content of guavas from various parts of the Transvaal and the Cape Province have been investigated by the writers. Ascorbic acid was estimated by titration with indophenol in aqueous or dioxane solution, after extraction of the material with a 2 per cent. solution of metaphosphoric acid. Canned guava juice was also assayed biologically by Key and Elphick's modification of the Hojer tooth method, the results being in agreement with those found by the chemical method.

The following results were obtained:—

Condition of fruit.	*Ascorbic acid content. (mg. per 100 g)*
Green and hard	250-350
Ripe and firm....	300-450
Over-ripe and soft	 50-100

It will be seen from this table that the amount of ascorbic acid present in the fruit increases as it ripens, but diminishes as the guava becomes soft. Firm fruit of high vitamin content may be stored at room temperature for several weeks without serious loss of vitamin, but when the guava is ripe or infected with fruit-fly, the value decreases rapidly.

There does not appear to exist a wide variation in the vitamin content of fruit of different varieties or from various districts. On the whole, however, white-fleshed guavas are usually slightly richer in ascorbic acid than those with pink flesh. Of the different parts of the fruit, the skin has the highest content, the inner pulp contains little, and the stones none at all. The proportion of ascorbic acid found in skin, outer pulp and inner pulp may be as high as 12 : 5 : 1.

When selected firm fruit is canned, the ascorbic acid present in fruit and juice may reach 200-300 mg. per 100 g. The use of soft fruit is attended by a sharp decrease in the vitamin content, values as low as 18 mg. per 100 g. being found in some cases. These low values also obtain under conditions favourable to the oxidation of the vitamin, such as pulping or overcooking.

The most successful procedure for the preservation of Vitamin-C in guavas has been found to be drying at low temperature. The unpeeled fruit is quartered, the central pulp and stones removed, and the residue blanched for two minutes. Thereafter the fruit is dried at 130° F. for 10-12 hours and powdered. Powdered guava prepared in this manner contains 2,500-3,000 mg. per 100 g. (white) and 2,000-2,500 mg. per 100 g. (pink). Failure to blanch the fruit prior to drying results in lower values (1,000-1,500 mg. per 100 g.). Thus, dried guavas compare favourably with other rich sources of the anti-scorbutic Vitamin-C, such as dried rose-hips, reported to contain 2,000 mg. ascorbic acid per 100 g. Moreover, the guava powder has a pleasant aromatic odour and practically no taste.

The above results, taken in conjunction with the wide distribution of the various species of guava and the ease with which they may be grown, justify their extensive cultivation and consumption.

* * *

Caffelite: A New Plastic.

For many years excess production of coffee has been a serious problem for the Brazilian Government; thousands of bags have been deliberately destroyed every year to prevent them coming on the market. Now that markets in Germany, Italy and other European countries are lost to them, the position is even more serious. According to the *Electrician* of 18th April, an investigation conducted in New York has led to the discovery of a new plastic material, which is known as 'Caffelite', and industrial plants will come into operation in Brazil this year in which at least part of the excess supply of coffee will be absorbed in the manufacture of Caffelite. The product is said to have useful electric properties at low frequencies. The material is moulded under pressure of one or two tons per square inch, and has a specific gravity of 1.43, that is, about 10 per cent. higher than wood flour filled phenolic moulding materials of the 'Bakelite' type. The other physical properties are stated to be similar to those of 'Bakelite', and it is claimed that all colours can be produced except white.—(*Nature*, Vol. CXLVII, No. 3735, 1941.)

* * *

Changes in Carotene and Ascorbic Acid Content of Mangoes during Ripening.

The vitamin C content of mangoes from the same tree shows considerable variation, that of the skin always exceeding that of the pulp. During ripening at room temperature (30-44°) C in the pulp diminishes from the green to the half-ripe stage and rises to a steady value during storage at room temperature or 0°. Half-ripe mangoes kept at 0° for 17 days do not ripen when brought to room temperature. The carotene content increases throughout ripening.—(*Brit. Chem. and Phys. Abstrs.*, A. III, p. 615.)

* This note has been transcribed from a Letter to *Nature* written by Messrs. Leon Golberg and Leopold Levy of the South African Institute of Medical Research and the Government Laboratories, Johannesburg, which was published in No. 3749 of that Journal, for 6th September, 1941, at p. 286.